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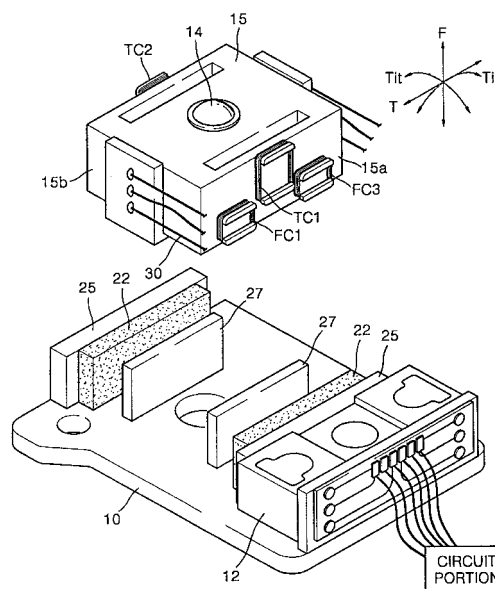
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(54) **Optical pickup actuator driving method**

(57) An optical pickup actuator provides coils for driving an optical pickup in a focus direction, a track direction, and a tilt direction, respectively. The coils are arranged at two opposite sides of a bobbin, thereby providing free space on the remaining sides of the bobbin. A focus coil (FC) is also used as a tilt coil. The optical pickup actuator is driven by arranging the focus and tilt coils into sets (e.g. FC1 & 2, FC3 & 4), and applying an input signal to each of the sets. Thus, since driving in the focus direction and the tilt direction can be controlled together by a single coil, the number of the support member can be reduced and a defect ratio can be lowered. Both three and four axes driving can be stably implemented.

FIG. 3



Description

[0001] The present invention relates to an optical pickup actuator driving method, and more particularly, to a method for driving an optical pickup actuator in which coil for driving an optical pickup in a focus direction, a track direction, and a tilt direction, respectively, are arranged ideally to minimise the number of coils and to increase free space on the bobbin.

[0002] In general, optical pickups are adopted in optical recording/reproducing apparatuses. An optical pickup performs recording and/or reproduction of information with respect to a recording medium such as an optical disk placed on a turntable in a non-contstep manner while moving in a radial direction of the optical disk.

[0003] The optical pickup includes an objective lens for forming a light spot on the optical disk by focusing light emitted from a light source, and an actuator for controlling the objective lens in a track direction, a focus direction, and a tilt direction so that the light spot formed by the objective lens can be accurately located on the optical disk.

[0004] The optical pickup actuator includes a double axes driving actuator for driving the optical pickup in the track direction and the focus direction. Recently, for high density recording, as the N/A of the objective lens recently increases and the wavelength of a laser decreases, margin in tilt of the optical pickup actuator decreases. To compensate for the reduced tilt margin, three axes or four axes driving actuators capable of driving an optical pickup in the tilt direction are needed in addition to the existing double axes driving actuator. The three axes driving means driving in the focus direction, the track direction, and the tilt direction. The four axes driving means driving in the focus direction, the track direction, a tilt radial direction, and a tilt tangential direction. Referring to Figure 1, the focus direction, the track direction, the tilt radial direction, and the tilt tangential direction are indicated by L-L', M-M', N, and O, respectively.

[0005] Referring to Figure 1, a conventional optical pickup actuator includes a base 100, a holder 103 fixed to the base 100, a bobbin 107 where an objective lens is mounted, wires 109 connecting the bobbin 107 to the holder 103, and a magnetic driving portion for moving the bobbin 107 in the track direction, the focus direction, or the tilt direction.

[0006] The magnetic driving portion includes a couple of a focus coil 110 and a tilt coil 112 (referring to Figure 2A) provided at each of the opposite side surfaces 107a of the bobbin 107, a track coil 115 arranged at the other side surfaces 107b where the focus coil 110 and the tilt coil 112 are not arranged, first and second magnets 117 and 119 installed on the base 100 to face the focus coil 110, the tilt coil 112, and the track coil 115 with a predetermined interval. Also, outer yokes 118 and 120 for fixing the first and second magnets 117 and 119 are installed on the base 100. Inner yokes 122 are installed

on the base 100 at a position facing the first magnet 117 to guide the bobbin 107. The outer yokes 118 and 120 and the inner yokes 122 guide path of magnetism generated by the first and second magnets 117 and 119 to direct a desired location.

[0007] Each of the wires 109 has one end soldered to both side surfaces of the bobbin 107 and the other end connected to the holder 103 and is electrically connected to a circuit portion for applying current to the magnetic driving portion.

[0008] In Figure 2A, an example of the polarity of the magnet and the direction of current is schematically shown to disclose the relationship of forces by the interstepion between the focus coil 110 and the tilt coil 112, and the first magnet 117 corresponding thereto. Here, the focus coil 110 provided at each of the opposite side surfaces 107a of the four side surfaces of the bobbin 107 receives a force F_f by Fleming's left hand rule so that the bobbin 107 is moved in the focus direction L. When the direction of the current changes to the opposite, the focus coil 110 receives a force in the opposite direction L'.

[0009] In the meantime, the tilt coil 112 is provided at both side surfaces 107a of the bobbin 107, forming a couple with the focus coil 110, and intersteps with the first magnet 117. Here, when the same current flowing the opposite directions are applied to the tilt coils 112, the forces F_{ti} received by the both tilt coils 112 become opposite so that the optical pickup is driven in the tilt direction, in particular, in the radial tilt direction (N).

[0010] Also, in Figure 2B, an example of the polarity of the magnet and the direction of current are schematically shown to disclose the relationship of forces by the interstepion between the track coil 115 and the second magnet 119 corresponding thereto. The direction and magnitude of forces between the magnet and the coil is determined by Fleming's left hand rule. Thus, the track coil 115 provided at each of the two side surfaces 107b of the fourth side surfaces of the bobbin 107 where the focus coil 110 and the tilt coil 112 are not arranged receives the force F_t in the track direction by the second magnet 119 so that the bobbin 107 moves in the track direction M. Here, when the direction of current I changes to the opposite, the track coil 115 receives a force in the opposite direction M'.

[0011] Typically, six wires 109 of the actuator are provided for the driving in the focus direction, the track direction, and the tilt direction. Further, more wires can be needed for the four axes driving actuator. However, since the optical pickup actuator is very small, when all four side surfaces of the bobbin 107 are used to install the focus coil, the track coil, or the tilt coil according to the conventional technology, no sufficient space is present for installation of the wire 109. In addition, when the number of wires increases, it is very difficult to attach the wires in a small space so that a defective ratio increases accordingly.

[0012] Also, when the coils are arranged using all four

side surfaces of the bobbin 107, wiring of the coils is complicated. Also, since the magnet is provided at each of the focus coil, the tilt coil, and the track coil, the number of part increases so that productivity is lowered. In addition, since interference with a spindle motor (not shown) for disc rotation is generated by the first magnet 117 for the focus coil arranged at the left and right sides of the bobbin 107, the spindle motor is not accurately controlled.

[0013] It is an aim of the present invention to provide an optical pickup actuator driving method in which coils for driving an objective lens in the focus direction, the track direction, and the tilt direction are arranged so that a sufficient space can be obtained on side surfaces of the bobbin and driving is controlled to minimise a number of parts required.

[0014] In one aspect of the present invention there is provided a method of driving an optical pickup actuator which comprises the steps of arranging a bobbin on a base to be capable of moving by a support member, installing at least one focus and tilt coil for driving the bobbin in focus and tilt directions and at least one track coil for driving the bobbin in a track direction at opposite side surfaces of the bobbin, and arranging a magnet to face the focus and tilt coil and the track coil, and dividing at least one of the focus and tilt coil into at least two sets of coils and applying an input signal to each of the sets.

[0015] It is preferred in the present invention that, in the step of applying an input signal, first and third focus and tilt coils are arranged at one side surface of the bobbin and second and fourth focus and tilt coils are arranged at the other side surface, and first and second input signals are input to first and second set coils formed by coupling two of the first through fourth focus and tilt coils.

[0016] It is preferred in the present invention that the first set coil is formed of first and third focus and tilt coils and the second set coil is formed of the second and fourth focus and tilt coils.

[0017] It is preferred in the present invention that the first set coil is formed of the first and second focus and tilt coils and the second set coil is formed of the third and fourth focus and tilt coils.

[0018] It is preferred in the present invention that the same input signal for focus driving is input as the first and second input signals.

[0019] It is preferred in the present invention that input signals having phases different from each other are input as the first and second input signals.

[0020] It is preferred in the present invention that a sum signal of a focus signal and a tilt signal having a phase different from that of the focus signal is input as the first and second input signals.

[0021] It is preferred in the present invention that the magnet is a magnet having four polarization.

[0022] It is preferred in the present invention that the magnet is at least two magnets each having two polarization.

[0023] It is preferred in the present invention that an input signal is input to the track coil independent of the focus and tilt coil.

[0024] It is preferred in the present invention that at least one of the focus and tilt coil and the track is formed of a fine pattern coil.

[0025] It is preferred in the present invention that the support member is arranged at other opposite side surfaces of the bobbin where the focus and tilt coil and the track coil are not arranged.

[0026] Also according to the present invention there is provided a method of driving an optical pickup actuator which comprises the steps of arranging a bobbin on a base to be capable of moving by a support member, installing at least one focus and tilt coil for driving the bobbin in focus and tilt directions and at least one track coil for driving the bobbin in a track direction at opposite side surfaces of the bobbin, and arranging a magnet to face the focus and tilt coil and the track coil, and independently inputting a signal to each focus and tilt coil.

[0027] It is preferred in the present invention that the same input signal is input to at least one focus and tilt coil to drive the bobbin in the focus direction.

[0028] It is preferred in the present invention that different input signals are applied to at least one focus and tilt coil to drive the bobbin in the tilt direction.

[0029] It is preferred in the present invention that, in the step of applying an input signal, the first and third focus and tilt coils are arranged at one side surface of the bobbin and the second and fourth focus and tilt coils are arranged at the other side surface opposite to the one side surface, first and second input signals are input to a first set coil and a second set coil, respectively, each set being formed of a selected couple of the first through fourth focus and tilt coils.

[0030] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figure 1 is an exploded perspective view of a conventional optical pickup actuator;

Figures 2A and 2B are views showing the relationship between the magnet and coil of the optical pickup actuator of Figure 1;

Figure 3 is an exploded perspective view of an optical actuator according to a preferred embodiment of the present invention;

Figure 4 is a plan view of the preferred optical pickup actuator;

Figure 5 is a view showing the preferred relationship in arrangement of the magnet and coil of the optical pickup actuator;

Figure 6 is a view showing the relationship in forces stepping between the magnet and a fine pattern coil of the optical pickup actuator according to the preferred embodiment of the present invention;

Figures 7A through 7C and Figure 8A through 8C are view showing waveforms of input signals to implement an optical pickup actuator driving method according to the preferred embodiment of the present invention; and

Figure 9 is a circuit diagram to implement the optical pickup actuator driving method according to the preferred embodiment of the present invention.

[0031] Before the description of a preferred method for driving an optical pickup actuator according to the present invention, an example optical pickup actuator to which the present invention is adopted is described as follows.

[0032] Referring to Figures 3 and 4, an optical pickup actuator according to a preferred embodiment of the present invention includes a base 10, a holder 12 provided at one side of the base 10, a bobbin 15 on which an objective lens 14 is mounted, and a magnetic driving portion for driving the bobbin 14 in a focus direction, a tilt direction, and a track direction.

[0033] The magnetic driving portion includes at least one focus and tilt coil, a track coil, which are provided at each of opposite side surfaces 15a of the bobbin 15, and a magnet 22 installed to face the focus and tilt coil and the track coil. For example, the focus and tilt coil may be first, second, third, and fourth focus and tilt coils FC1, FC2, FC3, and FC4 while the track coil may be first and second track coils TC1 and TC2 each of which is provided at each of two opposite side surfaces of the bobbin 15. Here, the first through fourth focus and tilt coils FC1, FC2, FC3, and FC4 and the first and second track coils TC1 and TC2 are all arranged at two opposing side surfaces 15a of the bobbin 15. A support member 30 for supporting the bobbin 15 capable of moving and simultaneously applying current to the first through fourth focus and tilt coils FC1, FC2, FC3, and FC4 and the first and second track coils TC1 and TC2 is arranged at each of the other two opposing side surfaces 15b of the bobbin 15 where the coils are not arranged. The support member 30 may be wires or leaf springs.

[0034] As shown in Figures 3 and 4, the preferred bobbin 15 is generally rectangular. The focus and tilt coils and the track coils are arranged on opposing first and second sides of the bobbin. The support members 30 are arranged on the other opposing third and fourth sides of the bobbin.

[0035] In the optical pickup actuator having the above structure, the first through fourth focus and tilt coils FC1, FC2, FC3, and FC4 are controlled to drive the object lens 14 both in the focus direction and the tilt direction.

[0036] The magnet 22 are divided by four, for exam-

ple, as shown in Figure 5. That is, the magnet 22 is divided into four sections in which N poles and S poles are appropriately distributed. For the convenience of explanation, the four divided magnet includes a first divided pole 22a, a second divided pole 22b, a third divided pole 22c, and a fourth divided pole 22d. The first divided pole 22a is an N pole, a second divided pole 22b is an S pole, a third divided pole 22c is an N pole, and a fourth divided pole 22d is an S pole. The focus and tilt coils FC1, FC2, FC3, and FC4 and the track coils TC1 and TC2 are arranged corresponding to the respective polarization 22a, 22b, 22c, and 22d of the magnet 22.

[0037] For example, each of the track coils TC1 and TC2 is arranged to face both of the first and second polarization 22a and 22b of the magnet 22, as shown in Figure 5. A couple of the first and third focus and tilt coils FC1 and FC3 are provided at the one side surface of the bobbin 15 and the other couple of the second and fourth focus and tilt coils FC2 and FC4 are provided at the other side surface of the bobbin 15. The first or second focus and tilt coil FC1 or FC2 can be arranged to face both of the second and third polarization 22b and 22c while the third or fourth focus and tilt coil FC3 or FC4 can be arranged to face both of the first and fourth polarization 22a and 22d.

[0038] Alternatively, the magnet 22 may be a magnet having two polarization. For example, a set of two magnet each having two polarization can be arranged to be separated a predetermined distance from each other to face the focus and tilt coils FC1, FC2, FC3, and FC4 and the track coils TC1 and TC2.

[0039] Here, the focus and tilt coils FC1, FC2, FC3, and FC4 and the track coils TC1 and TC2 can be winding coils. Also, as shown in Figure 6, at least one of the focus and tilt coils and the track coils can be a fine pattern coil 20. The fine pattern coil 20 is manufactured by patterning a coil shape on a film and can be very useful in installation of a coil in a small space.

[0040] Although the magnet 22 can have four polarization which are divided symmetrically, to secure effective areas of the track coils TC1 and TC2, the first and second polarization 22a and 22b corresponding to the track coils TC1 and TC2 can be divided to have areas greater than those of the third and fourth polarization 22c and 22d. That is, since the focus and tilt coils FC1, FC2, FC3, and FC4 use all the first through fourth polarization 22a, 22b, 22c, and 22d while the track coils TC1 and TC2 use only the first and second polarization 22a and 22b, each of areas of the polarization can be adjusted for the balance with respect to the focus and tilt coils FC1, FC2, FC3, and FC4.

[0041] Also, a neutral zone 22 can be arranged between the respective polarization 22a, 22b, 22c, and 22d of the magnet 22. The neutral zone 22 is provided at a boundary portion between the respective polarization to prevent lowering of the overall lines of magnetic force as the lines of magnetic force are offset at a boundary area where the magnetic poles are opposite.

[0042] An outer yoke 25 and an inner yoke 27 may be further provided to guide lines of magnetic force generated by the magnet 22 in a desired direction.

[0043] Next, a method of driving an optical pickup actuator according to a preferred embodiment of the present invention is described below.

[0044] At least one focus and tilt coils FC1, FC2, FC3, and FC4 and the track coils TC1 and TC2 are arranged at both side surfaces 15a of the bobbin 15. At least one focus and tilt coil is divided into at least two sets to receive first and second input signals.

[0045] For example, as shown in Figure 7A, when the first and second input signals are focus signals in the same direction, the bobbin 15 moves in the focus direction F. In detail, in the case in which the first and second focus and tilt coils FC1 and FC2 constitute a first set coil and the third and fourth focus and tilt coils FC3 and FC4 constitute a second set coil, when the same signal is applied to both of the first and second set coils, the first through fourth focus and tilt coils FC1, FC2, FC3, and FC4 receive the same forces in the upward or downward direction by the interstepion with the magnet 22. Thus, the bobbin 15 can be driven in the focus direction F.

[0046] In contrast, when first and second input signals different from each other are input to the first and second focus and tilt coils FC1 and FC2 and the third and fourth focus and tilt coils FC3 and FC4, the focus and tilt coils receive forces in the upward or downward direction that is opposite to each other at the left and right sides. Here, when the first input signal as shown in Figure 7B is input to the first and second focus and tilt coils FC1 and FC2, the second input signal having a phase different from that of the first input signal is input to the third and fourth focus and tilt coils FC3 and FC4, as shown in Figure 8B. Thus, driving of the bobbin 15 in a tilt radial direction Tir can be controlled.

[0047] As describe above, by constituting the first and second focus and tilt coils FC1 and FC2 and the third and fourth focus and tilt coils FC3 and FC4 as the first set coil and the second set coil, respectively, driving of the bobbin along three axes of the focus direction F, the track direction T, and the radial tilt direction Tir is possible. Figure 9 is a circuit diagram for the above case.

[0048] Unlike the above case, the first and third focus and tilt coils FC1 and FC3 of the first through fourth focus and tilt coils FC1, FC2, FC3, and FC4 may form a first coil set and the second and fourth focus and tilt coils FC2 and FC4 may form a second coil set. Here, when first and second input signals having phases different from each other are input to the first set coil and the second set coil, respectively, driving in the tangential tilt direction Tit is possible.

[0049] In addition to the above method of independently controlling driving in the focus direction and driving in the tilt direction, there is a method of simultaneously controlling the driving in the focus direction and the driving in the tilt direction by applying a sum signal of the first and second input signals for driving in the tilt direc-

tion as a signal for driving in the focus direction. That is, a sum signal (Figure 7C) of the focus driving signal (Figure 7A) and the first input signal (Figure 7B) for driving in the tilt direction is input to the first set coil. A sum signal (Figure 8C) of the focus driving signal (Figure 8A) and the second input signal (Figure 7C) for driving in the tilt direction is input to the second set coil. Thus, driving in the focus direction F, the tilt radial direction Tir or the tilt radial direction can be controlled simultaneously.

[0050] Here, the first set coil is formed of the first and second focus and tilt coils FC1 and FC2 and the second set coil is formed of the third and fourth focus and tilt coils FC3 and FC4. By doing so, the driving in the focus direction F and the driving in the radial tilt direction Tir can be controlled together. Alternatively, the first set coil can be formed of the first and third focus and tilt coils FC1 and FC3 and the second set coil is formed of the second and fourth focus and tilt coils FC2 and FC4. By doing so, the driving in the focus direction F and the driving in the tangential tilt direction Tit can be controlled together.

[0051] As another preferred embodiment, there is a method of independently applying a signal to each of the first through fourth focus and tilt coils FC1, FC2, FC3, and FC4. When the focus signal (Figures 7A and 8A) is identically applied to the first through fourth focus and tilt coils, the bobbin 15 move up and down and is driven in the focus direction F.

[0052] In contrast, the driving in the tilt radial direction Tir and the driving in the tilt tangential direction Tit can be controlled by selectively inputting an input signal to each of the first through fourth focus and tilt coils FC1, FC2, FC3, and FC4. For example, the first and second focus and tilt coils FC1 and FC2 of the first through fourth focus and tilt coils FC1, FC2, FC3, and FC4 can form a first set and the third and fourth focus and tilt coils FC3 and FC4 can form a second set. Also, the first and third focus and tilt coils FC1 and FC3 can form a first set and the second and fourth focus and tilt coils FC2 and FC4 can form a second set.

[0053] Here, by inputting a predetermined first input signal (Figure 7B) to the first set and the second input signal having a phase different from that of the first input signal to the second set, the driving in the tilt radial direction Tir and in the tilt tangential direction Tit can be selectively controlled.

[0054] Also, a sum signal of the focus signal and the first or second input signal for tilt driving can be selectively input to the first through fourth focus and tilt coils FC1, FC2, FC3, and FC4. By doing so, the driving in the focus direction, the driving in the radial tilt direction or the driving in the tangential tilt direction can be controlled together.

[0055] In the meantime, the track coils TC1 and TC2 move the bobbin 15 in the track direction T by the interstepion with the first divided pole 22a and the second divided pole 22b. Thus, four axes driving in the focus direction F, the track direction T, the radial tilt direction

Tir, and the tangential tilt direction Tit is possible.

[0056] The arrangement of the polarization of the magnet and the coils can be modified beyond the specific examples mentioned above, whilst remaining within the scope of the technical concept of the present invention.

[0057] As described above, in the preferred optical pickup actuator driving method according to the present invention, since the focus and tilt coils and the track coils are provided at the opposite side surfaces of the bobbin to secure a free space at the other opposite side surfaces of the bobbin, driving in the focus direction and driving in the tilt direction can be controlled together by a single coil. Therefore, the support member can be easily installed at the other opposite side surfaces of the bobbin and the number of the support member can be reduced. Thus, defective ratio can be lowered and the three axes driving and the four axes driving can be stably implemented.

[0058] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0059] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0060] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0061] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A method of driving an optical pickup actuator comprising the steps of:

arranging a bobbin (15) on a base (10) to be capable of moving by a support member (30) ;

installing at least one focus and tilt coil (FC1) for driving the bobbin in focus and tilt directions and at least one track coil (TC1) for driving the

bobbin in a track direction at opposite side surfaces of the bobbin, and arranging a magnet (22) to face the focus and tilt coil and the track coil; and

dividing at least one of the focus and tilt coil into at least two sets of coils and applying an input signal to each of the sets.

2. The method as claimed in claim 1, wherein, in the step of applying an input signal, first and third focus and tilt coils (FC1,FC3) are arranged at one side surface of the bobbin (15) and second and fourth focus and tilt coils (FC2,FC4) are arranged at the other side surface, and first and second input signals are input to first and second sets of coils formed by coupling pairs of the first through fourth focus and tilt coils.
3. The method as claimed in claim 2, wherein the first set coil is formed of first and third focus and tilt coils (FC1,FC3) and the second set coil is formed of the second and fourth focus and tilt coils (FC2,FC4).
4. The method as claimed in claim 2, wherein the first set coil is formed of the first and second focus and tilt coils (FC1,FC2) and the second set coil is formed of the third and fourth focus and tilt coils (FC3,FC4).
5. The method as claimed in either claim 3 or claim 4, wherein the same input signal for focus driving is input as the first and second input signals.
6. The method as claimed in either claim 3 or claim 4, wherein input signals having phases different from each other are input as the first and second input signals.
7. The method as claimed in either claim 3 or claim 4, wherein a sum signal of a focus signal and a tilt signal having a phase different from that of the focus signal is input as the first and second input signals.
8. The method as claimed in any preceding claim, wherein the magnet is a magnet having four polarization.
9. The method as claimed in any preceding claim, wherein the magnet is at least two magnets each having two polarization.
10. The method as claimed in any preceding claim, wherein an input signal is input to the track coil (TC) independent of the focus and tilt coil (FC).
11. The method as claimed in any preceding claim, wherein at least one of the focus and tilt coil (FC) and the track coil (TC) is formed of a fine pattern

coil.

12. The method as claimed in any preceding claim, wherein the support member (30) is arranged at other opposite side surfaces of the bobbin (15) where the focus and tilt coil (FC) and the track coil (TC) are not arranged. 5
13. The method as claimed in claim 11, wherein the support member is formed of a wire or a leaf spring. 10
14. The method as claimed in claim 11 or 12, wherein the number of the support members are at least six.
15. The method as claimed in any preceding, further comprising an outer yoke (25) to which the magnet (22) is fixed and an inner yoke (27) corresponding to the outer yoke. 15
16. The method as claimed in any preceding claim, wherein an objective lens (14) is mounted on the bobbin (15). 20
17. A method of driving an optical pickup actuator comprising the steps of: 25
 - arranging a bobbin (15) on a base (10) to be capable of moving by a support member (30);
 - installing at least one focus and tilt coil (FC) for driving the bobbin in focus and tilt directions and at least one track coil (TC) for driving the bobbin in a track direction at opposite side surfaces of the bobbin, and arranging a magnet (22) to face the focus and tilt coil and the track coil; and 30
 - independently inputting a signal to each focus and tilt coil (FC). 35
18. The method as claimed in claim 17, wherein the same input signal is input to at least one focus and tilt coil (FC) to drive the bobbin in the focus direction. 40
19. The method as claimed in claim 17, wherein different input signals are applied to at least one focus and tilt coil (FC) to drive the bobbin in the tilt direction. 45
20. The method as claimed in any of claims 17 through 19, wherein, in the step of applying an input signal, first and third focus and tilt coils (FC1,FC3) are arranged at a first side surface of the bobbin and second and fourth focus and tilt coils (FC2,FC4) are arranged at a second side surface opposite to the first side surface, first and second input signals are input to a first set coil and a second set coil, respectively, each set being formed of a selected couple of the 50 55

first through fourth focus and tilt coils (FC1-FC4).

21. The method as claimed in claim 20, wherein the first set coil is formed of the first and third focus and tilt coils (FC1,FC3) and the second set coil is formed of the second and fourth focus and tilt coils (FC2,FC4).
22. The method as claimed in claim 20, wherein the first set coil is formed of the first and second focus and tilt coils (FC1,FC2) and the second set coil is formed of the third and fourth focus and tilt coils (FC3,FC4).
23. The method as claimed in either claim 21 or claim 22, wherein the same input signal for focus driving is input as the first and second input signals.
24. The method as claimed in either claim 21 or claim 22, wherein input signals having phases different from each other are input as the first and second input signals.
25. The method as claimed in either claim 21 or claim 22, wherein a sum signal of a focus signal and a tilt signal having a phase different from that of the focus signal as the first and second input signals.

FIG. 1

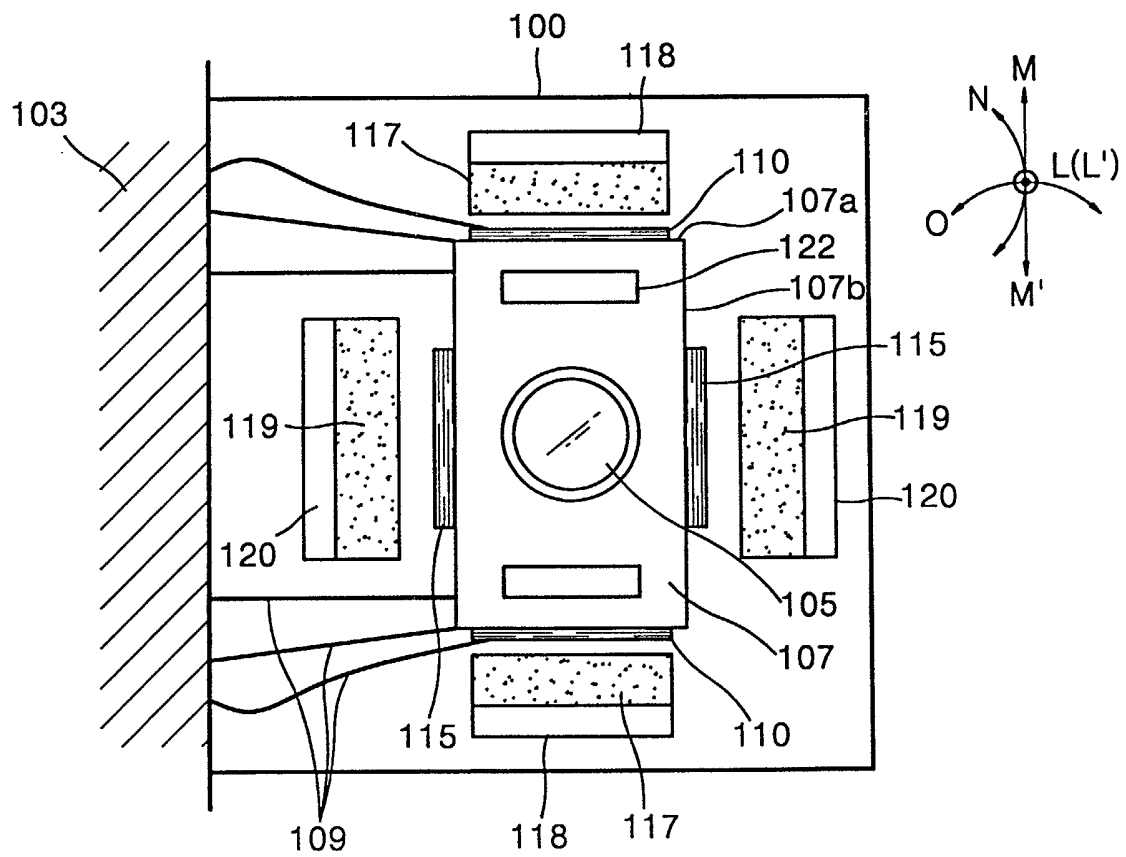


FIG. 2A

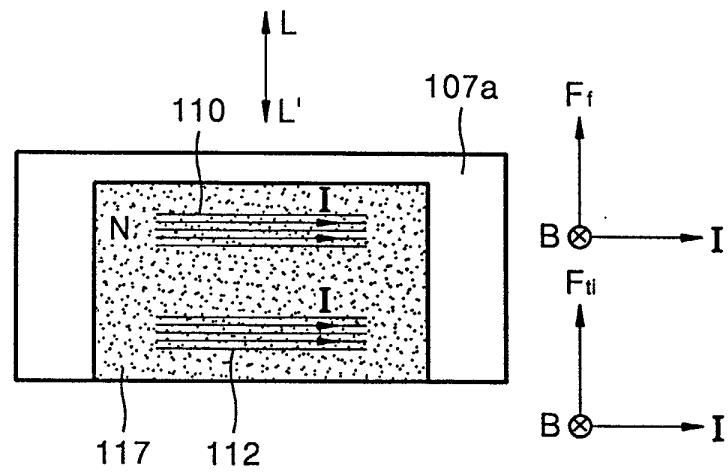


FIG. 2B

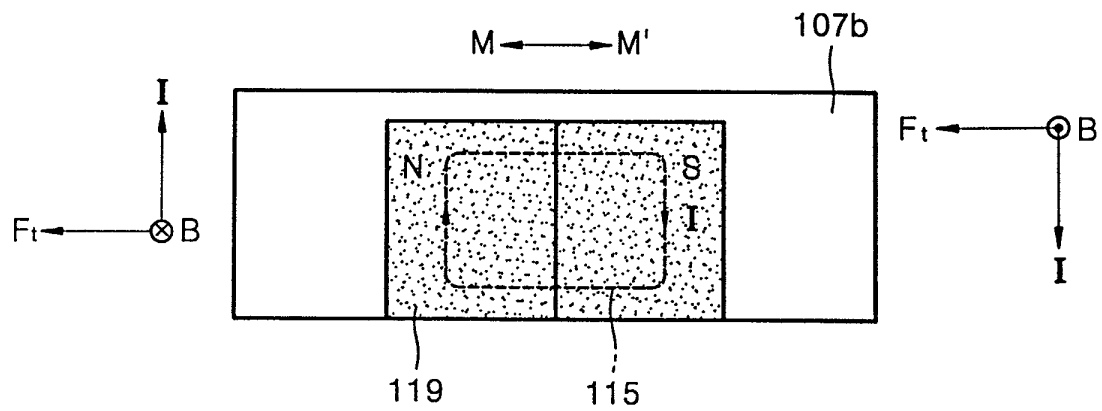


FIG. 3

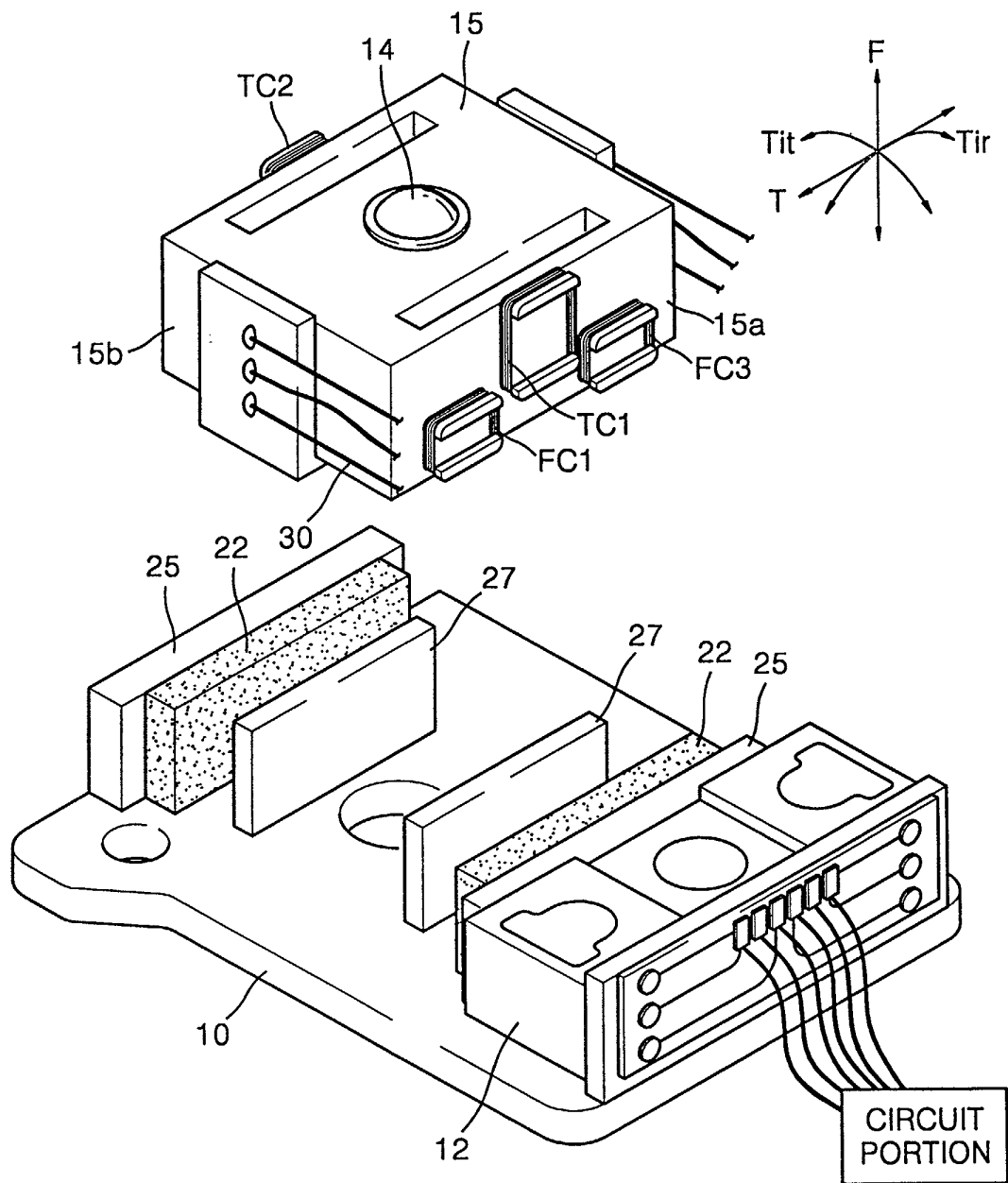


FIG. 4

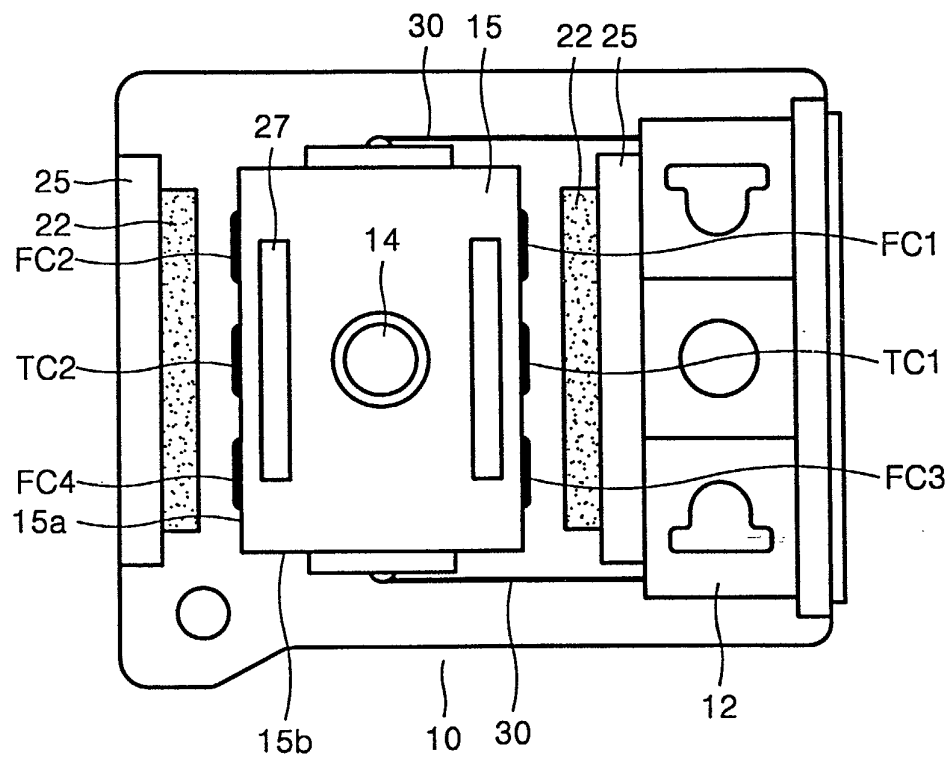


FIG. 5

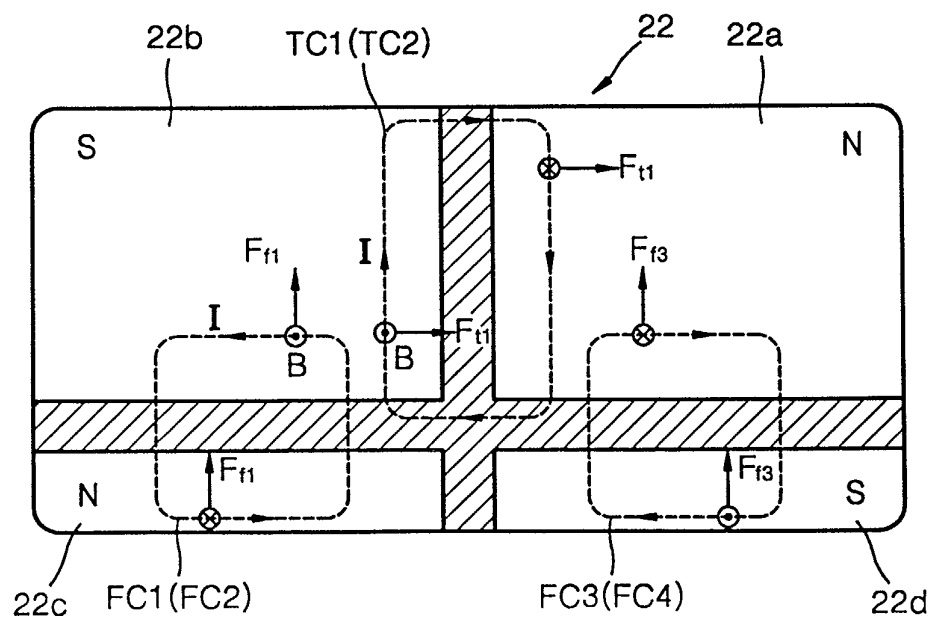


FIG. 6

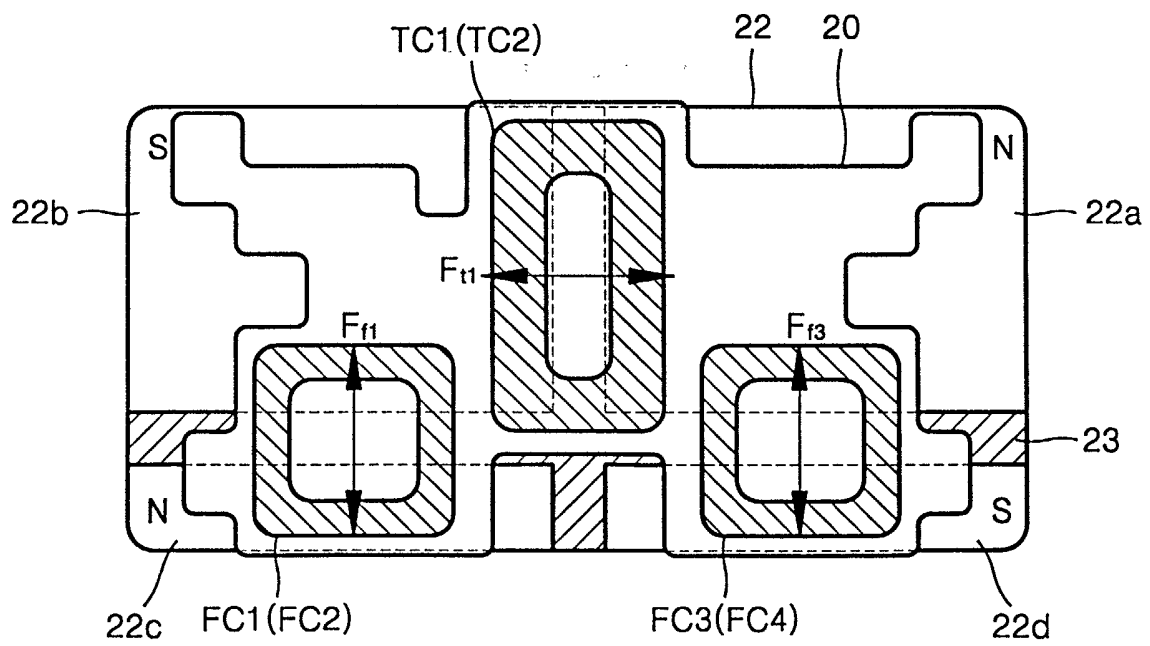


FIG. 7A

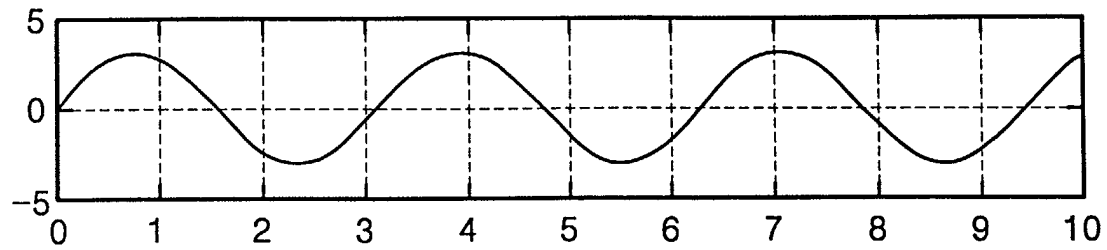


FIG. 7B

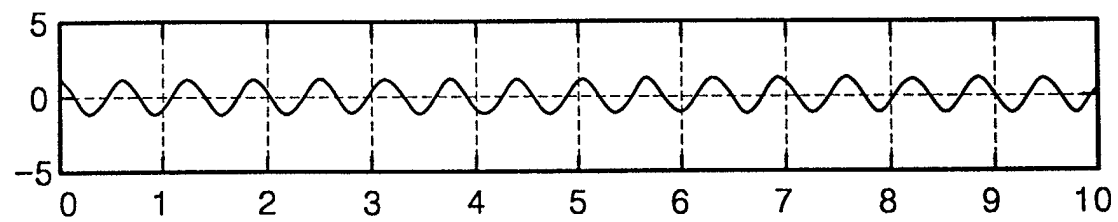


FIG. 7C

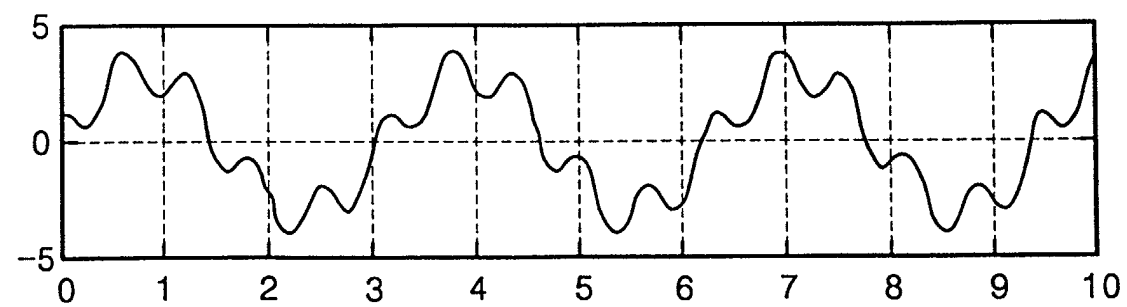


FIG. 8A

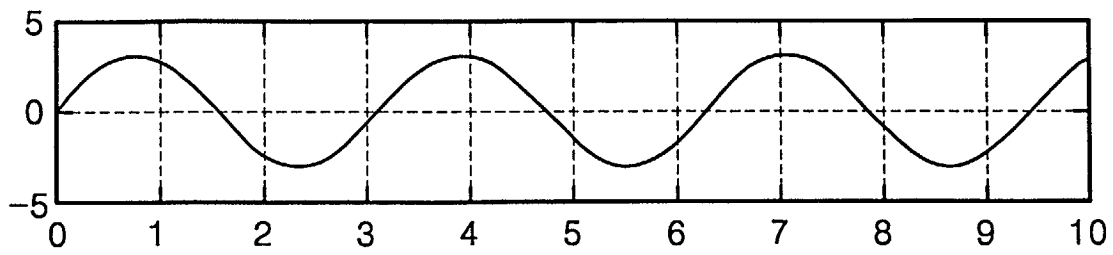


FIG. 8B

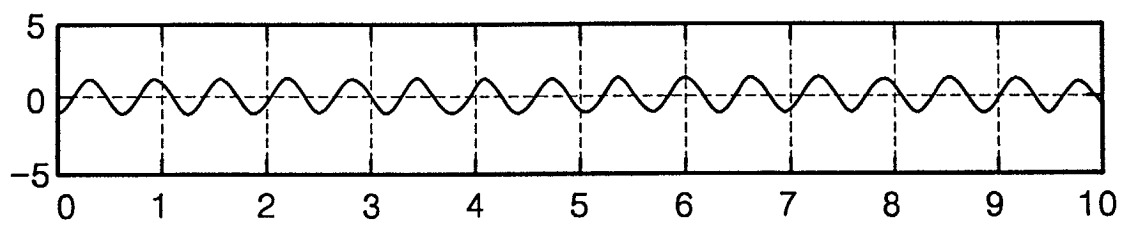


FIG. 8C

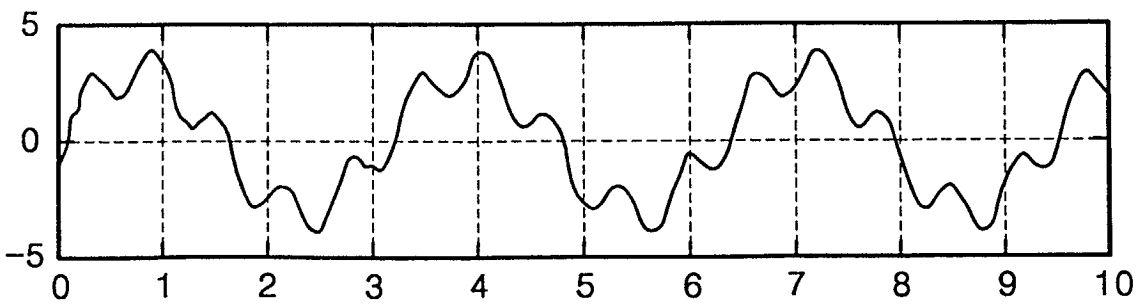


FIG. 9

